CLAIMS

What Is Claimed Is:

1.An adjustable nanopore comprising:

a first substrate having a sharp concave first corner therein, the first corner being bounded by a first surface of the first substrate, the first corner having a radius of curvature less than 100 nm;

a second substrate having a second edge bounded by a second surface of the second substrate;

wherein the first surface is placed in contact with the second surface so as to create a pore bounded by the first corner and the second edge; and

an adjustable mechanism for increasing and reducing the minimum distance from the second edge to the first corner in a range including a minimum distance less than 100 nm.

2. The nanopore of Claim 1 wherein the minimum distance from the second edge to the first corner is less than 10 nm.

3. The nanopore of Claim 2 wherein the minimum distance from the second edge to the first corner is less than 2 nm.

4. The nanopore of Claim 3 wherein the minimum distance from the second edge to the first corner is less than 1 nm.

5. The nanopore of Claim 1 wherein the adjustable mechanism is selected from the group consisting of mechanical positioners, piezoelectric positioners, electromagnetic positioners, and electrostatic positioners.

6. The nanopore of Claim 1 further including a mechanism for monitoring the size of the pore.

7. The nanopore of Claim 6 wherein the mechanism for monitoring the size of the pore includes the ability to monitor an ionic current through the pore.

8. The nanopore of Claim 6 wherein the adjustable mechanism is coupled to the mechanism for monitoring the size of the pore to create a feedback loop for controlling the size of the pore.

9. The nanopore of Claim 8 wherein the feedback loop is selected from the group consisting of electronic feedback loops and computer controlled feedback loops.

10.The nanopore of Claim 1 wherein at least one of the first and second substrates is a monocrystalline substrate.

11. The nanopore of Claim 10 wherein the monocrystalline substrate is selected from the group consisting of silicon, germanium, quartz, and diamond.

12. The nanopore of Claim 11 wherein the monocrystalline substrate is selected from the group consisting of silicon, germanium, and diamond, and wherein the monocrystalline substrate has at least one of major surface being substantially perpendicular to a crystalline direction selected from the group consisting of [100] directions, [110] directions, and [111] directions.

13. The nanopore of Claim 1 wherein at least one of the first and second substrates is a polycrystalline substrate.

14. The nanopore of Claim 13 wherein the polycrystalline substrate is selected from the group consisting of silicon, germanium, quartz, and diamond.

15. The nanopore of Claim 1 wherein at least one of the first and second substrates is an amorphous substrate.

16. The nanopore of Claim 15 wherein the amorphous substrate is selected from the group consisting of glasses and ceramics.

17. The nanopore of Claim 1 wherein the first and second substrates are oriented such that the first corner is opposed by the second edge to form a triangular aperture.

18. The nanopore of Claim 17 wherein the triangular aperture is an isosceles triangle.

19. The nanopore of Claim 17 wherein the triangular aperture is an asymmetrical triangle.

20. The nanopore of Claim 17 further including an angular orientation mechanism to change the relative angle of the second edge to the first corner so as to vary the angles of the triangular aperture.

21. The nanopore of Claim 1 wherein the second substrate has a second sharp corner therein, the second corner being bounded by the second surface of the second substrate, the second corner being placed at a termination of the second edge, the second corner having a radius of curvature less than 100 nm, and wherein the first and second substrates are oriented such that the first corner and the second corner combine to form a rhomboidal aperture.

22. The nanopore of Claim 21 further including an angular orientation mechanism to change the relative angle of the second corner to the first corner so as to vary the angles of the rhomboidal aperture.

23. The nanopore of Claim 1 further including an anti-stiction layer disposed on at least one of the first surface and the second surface.

24. The nanopore of Claim 23 wherein the anti-stiction layer is selected from the group consisting of diamond, diamond-like carbon, silicon carbide, a self-assembled monolayer comprising dichlorodimethylsilane, octadecyltrichlosilane, dodecyltrichlorosilane, or perfluorodecyltrichlorosilane, alkanethiols, and molecular films based on the free radical reaction of a primary alkene with hydrogen terminated silicon.

25. A method for fabricating a nanopore, comprising:

providing a first substrate having a flat first major surface,

forming a sharp concave first corner in the first substrate, the first corner intersecting the first major surface,

providing a second substrate having a flat major second surface,

forming a sharp second edge bounded by the second surface,

placing the first surface in contact with the second surface in such a fashion that the second edge and the first corner form an aperture, and

providing adjustment means to control the minimum distance from the second edge to the first corner.

26. The method of Claim 25 wherein the minimum distance between the second edge and the first corner includes a range from zero to 100 nm.

27. The method of Claim 25 wherein the first corner is formed utilizing chemical etching.

28. The method of Claim 27 wherein the chemical etching comprises orientation-dependent etching.

29. The method of Claim 28 wherein the orientation-dependent etching utilizes an etch composition selected from the group consisting of tetramethyl ammonium hydroxide in water, ammonium hydroxide in water, sodium hydroxide in water, a mixture of ethylenediamine and pyrocatechol in water, potassium hydroxide in water, a mixture of potassium hydroxide and isopropanol in water, a mixture of potassium hydroxide and aluminum in water, cesium hydroxide in water, hydrazine in water, and rubidium hydroxide in water.

30. The method of Claim 25 wherein the first corner is formed by a procedure selected from the group consisting of cleaving, chipping, spalling, flaking, exfoliating, and knapping.

31. The method of Claim 25 wherein the second edge is formed utilizing chemical etching.

32. The method of Claim 31 wherein the chemical etching is orientation-dependent etching.

33. The method of Claim 32 wherein the orientation-dependent etching utilizes an etch composition selected from the group consisting of tetramethyl ammonium hydroxide in water, ammonium hydroxide in water, sodium hydroxide in water, a mixture of ethylenediamine and pyrocatechol in water, potassium hydroxide in water, a mixture of potassium hydroxide and isopropanol in water, a mixture of potassium hydroxide and aluminum in water, cesium hydroxide in water, hydrazine in water, and rubidium hydroxide in water.

34. The method of Claim 25 wherein the second edge is formed by a procedure selected from the group consisting of cleaving, chipping, spalling, flaking, exfoliating, and knapping.

35. The method of Claim 25 wherein at least one of the first corner and the second edge is sharpened by oxidative sharpening.

36. The method of Claim 25 wherein at least one of the first and second substrates is a monocrystalline substrate.

37. The method of Claim 36 wherein the monocrystalline substrate is selected from the group consisting of silicon, germanium, quartz, and diamond.

38. The method of Claim 37 wherein the monocrystalline substrate is selected from the group consisting of silicon, germanium, and diamond, and wherein the substrate has at least one of major surface being substantially perpendicular to a crystalline direction selected from the group consisting of [100] directions, [110] directions, and [111] directions.

39. The method of Claim 25 wherein at least one of the first corner and the second edge is formed by chemical etching of a hole completely through at least one of the first substrate and the second substrate, respectively.

40. The method of Claim 25 further comprising providing an anti-stiction layer on at least one of the first and second surfaces.

41. The method of Claim 40 wherein the anti-stiction layer is selected from the group consisting of diamond, diamond-like carbon, silicon carbide, a self-assembled monolayer comprising dichlorodimethylsilane, octadecyltrichlosilane, dodecyltrichlorosilane, or perfluorodecyltrichlorosilane, alkanethiols, and molecular films based on the free radical reaction of a primary alkene with hydrogen-terminated silicon.

42. The method of Claim 25 wherein the first and second substrates are oriented such that the first corner is opposed by the second edge to form a triangular aperture.

43. The method of Claim 42 wherein said triangular aperture is an isosceles triangle.

44. The method of Claim 42 wherein said triangular aperture is an asymmetrical triangle.

45. The method of Claim 42 further including providing an angular orientation mechanism to change the relative angle of the second edge to the first corner so as to vary the angles within the triangular aperture.

46. The method of Claim 25 wherein the second substrate has a second sharp corner therein, the second corner being bounded by the second surface of the second substrate, the second corner being placed at a termination of the sharp second edge, the second corner having a radius of curvature less than 100 nm, and wherein the first and second substrates are oriented such that the first corner and the second corner combine to form a rhomboidal aperture.

47. The method of Claim 46 further including providing an angular orientation mechanism to change the relative angle of the second edge to the first corner so as to vary the angles within the rhomboidal aperture.

48. A method of at least one of characterizing and handling at least one substance selected from the group consisting of molecules, molecular complexes, and supramolecular complexes, comprising:

providing a nanopore having a width, the nanopore including a mechanism for adjusting the width of the nanopore;

placing the nanopore in an ionic solution containing at least one copy of the substance to be characterized so that a continuous path of the ionic solution through the nanopore is established;

adjusting the width of the nanopore to a desired first width;

establishing an ionic electric current of desired direction and magnitude through the nanopore; and

sensing at least one of the entrance into the nanopore of the substance to be characterized and the blockage by the nanopore of the path of the substance to be characterized, the sensing occurring by means of a change in the magnitude of the ionic current.

49. The method of Claim 48 wherein the substance has a long chain structure.

50. The method of Claim 48 wherein variations in ionic current as the substance passes through the adjustable nanopore provide information about the structure of the substance.

51. The method of Claim 48 wherein the first width of the adjustable nanopore is small enough to block the passage of the substance at a first point of the structure of the substance.

52. The method of Claim 51 wherein, after the passage of the substance is blocked, the width of the nanopore is subsequently increased to a second width sufficient to allow the substance to begin to proceed again through the nanopore.

53. The method of Claim 52 wherein monitoring the increasing width of the nanopore to a second width just sufficient to allow the substance to begin to proceed through the nanopore provides information about the structure of the substance.

54. The method of Claim 52 wherein the substance has a long chain structure, and wherein after the substance begins to proceed again through the nanopore, the width of the nanopore is subsequently decreased to a third width while the substance is still proceeding through the nanopore.

55. The method of Claim 54 wherein the width of the nanopore is decreased to a third width sufficiently small to subsequently block the passage of the substance at a second point along the structure of the substance.

56. The method of Claim 55 wherein the third width is less than or equal to the second width, so that the substance becomes trapped by the nanopore between the first point and the second point of the substance.

57. The method of Claim 56 wherein at least one of the direction and magnitude of the ionic current is subsequently varied in order to provide information about the structure of the substance.

58. A method of cleaving at least one substance selected from the group consisting of molecules, molecular complexes, and supramolecular complexes, comprising:

providing a nanopore comprising

a first substrate having a sharp concave first corner therein, the first corner being bounded by a first surface of the first substrate, the first corner having a radius of curvature less than 100 nm,

a second substrate having a sharp second edge bounded by a second surface of the second substrate,

wherein the first surface is placed in contact with the second surface so as to create a pore bounded by the first corner and the second edge, and

an adjustable mechanism for increasing and decreasing the width of the nanopore, the width being the minimum distance between the second edge and the first corner;

placing the nanopore in an ionic solution containing at least one copy of the substance to be cleaved so that a continuous path of the ionic solution through the nanopore is established;

adjusting the width of the nanopore to a desired first width;

establishing an ionic electric current of desired direction and magnitude through the nanopore;

sensing the presence in the nanopore of the substance to be cleaved, the sensing occurring by means of a change in the magnitude of the ionic current; and

decreasing the width of the nanopore to a second width small enough to cleave the substance.

59. The method of Claim 58, wherein the substance to be cleaved has a long chain structure, and further including employing the nanopore to block the passage of the substance at a desired location along the substance before the substance is cleaved.

60. The method of Claim 59, further including employing the nanopore to trap a section of the substance before the substance is cleaved.

61. A method of capturing at least one substance selected from the group consisting of molecules, molecular complexes, and supramolecular complexes, comprising:

providing a nanopore comprising

a first substrate having a sharp concave first corner therein, the first corner being bounded by a first surface of the first substrate, the first corner having a radius of curvature less than 100 nm,

a second substrate having a sharp second edge bounded by a second surface of the second substrate,

wherein the first surface is placed in contact with the second surface so as to create a pore bounded by the first corner and the second edge, and

an adjustable mechanism for increasing and decreasing the width of the nanopore, the width being the minimum distance between the second edge and the first corner;

placing the nanopore in an ionic solution containing at least one copy of the substance to be captured so that a continuous path of the ionic solution through the nanopore is established;

adjusting the width of the nanopore to a desired first width;

establishing an ionic electric current of desired direction and magnitude through the nanopore;

sensing the presence in the nanopore of the substance to be captured, the sensing occurring by means of a change in the magnitude of the ionic current; and

decreasing the width of the nanopore to a second width small enough to capture the substance and hold it.

62. The method of Claim 61, wherein the substance to be captured has a long chain structure, and further including employing the nanopore to block the passage of the substance at a desired location along the substance before the substance is captured.

63. The method of Claim 62, further including employing the nanopore to trap a section of the substance before the substance is captured.